By KENNETH L. LAY and KENT L. JONES

Economic Impact of Defense Procurement

The Office of Business Economics is vitally interested in improving the measurement of the impact of defense activity on the economy, as reflected in the national income and product accounts. The econometric work presented in this article indicates that the time-of-delivery method used for recording most defense transactions in the national accounts has given inadequate signals of the impact of defense activity since the mid-1960's. The work presented here suggests the extent to which the NIA series on defense purchases and the Federal fiscal position may have understated both the expansionary impact of defense activity in the mid-1960's and the impact of the more recent decline. These findings reinforce the desirability of developing better statistics bearing on this subject within the framework of the national income and product accounts.

The work described here was originally carried out by the authors as an adjunct to a study by the Defense Department aimed at implementing an accrual accounting system. At the time, both authors were on active duty as officers in the U.S. Navy Reserve, assigned to the Office of the Assistant Secretary of the Navy for Financial Management.

THE U.S. economy has had to adjust in the recent past to large changes in defense activity. Government purchases of goods and services for national defense appear to be stabilizing now, but this follows a decline from an annual rate of $79.4 billion in the fourth quarter of 1968 to $71.8 billion in the second quarter of 1971. If military and civilian employee compensation is excluded in order to focus on purchases from the private economy, the decline was even greater. Total defense purchases fell from 8.9 percent to 6.9 percent of GNP over this period, and purchases from the private economy from 6.0 percent to 4.1 percent of private GNP.

This reduction has many implications for economic policy. A significant change in defense spending affects the fiscal posture of the Government, the distribution of resources between the private and public sectors, and the proportions of the Nation's output which are available for defense and civilian purposes. Sudden shifts in defense programs can create imbalances in the economy which require compensatory adjustments in monetary and fiscal policy.

Despite the subject's importance, information on defense activity is inadequate for the needs of economists and policymakers. One of the major shortcomings is that there is little reliable information on defense production, a key variable in gaging the impact of defense activity on the economy. In the national income and product accounts, which are the main tool for studying the economic impact of defense activity, that activity is measured by purchases (deliveries). This is unsatisfactory, because much of the impact occurs earlier, when production takes place. Total defense production cannot be measured in the present national accounts framework because adequate data are lacking on the change in inventories of defense goods, which must be added to purchases in order to get the measure of total production. (Defense inventories are included in GNP as part of change in business inventories (CBI), but are not separately identified.) One of the aims of this article is to gage the magnitude of defense production and defense inventory change.

The data source for this study is a sample of 51 defense procurement contracts largely awarded during the Vietnam buildup. The data were collected from contractors in 1969 by a Defense Department study group as part of the Government's effort to implement an accrual accounting system.

Based upon an analysis of these contracts, this article will (1) discuss the sample data on obligations, production, payments, and deliveries, (2) use a statistical model to estimate defense production during the 1965–71 period, (3) adjust the national accounts (NIA) series on defense purchases, CBI, and Federal Government surplus or deficit to reflect the estimates derived from the model, (4) suggest several possible data problems, and (5) explain in detail the mathematical derivation of the model.

Most important, the article will show that the time-of-delivery method used for recording most defense transactions in the national income and product accounts has given inadequate signals of the impact of defense activity on the economy during the Vietnam war period. Specifically, the article will show that the delivery method of recording defense goods and business inventories understated the expansionary impact of defense activity from mid-1965 through 1966 and understated the impact of the decline since late 1968.

The Sample Data

As noted earlier, the sample data were collected as part of the Defense Department's work in establishing a system of accrual accounting. Along with other Government agencies, the

Table 1.—Characteristics of Defense Contract Sample

Contract characteristics	Number of contracts
Procurement program:	
Aircraft	23
Missile	15
Electronics	11
Other	2
Size: (Million $)	
Over 200 million	2
100–200	5
50–100	12
25–50	5
5–25	9
1–5	12
Period of initial production:	
Before April 1965	20
April 1965–March 1966	16
After March 1966	15
Pricing provision:	
Fixed price	43
Cost plus	8
Military Service:	
Navy	35
Air Force	16

Source: *A Final Report on the Proceedings of the DOD Special Study Group on Defense Contractor Constructive Delivery (Accrual Accounting Implementation)*, May 1, 1970.

DOD is working toward recording expenditures on an accrual rather than a cash basis, as recommended by a Presidential Commission in 1967.[1] For work produced to Government order, such as on defense procurement contracts, accrued expenditures are to be recorded at the time of "constructive delivery," defined as the time when contractors perform work and incur costs on the contracts.[2] (Goods purchased "off-the-shelf" would be recorded under the accrual concept at the time of physical delivery; employee compensation and other payments for services would be recorded at the time of performance.)

The procurement contract sample

It was not possible to derive the sample of contracts used in this study in a scientific manner because information on the characteristics of the total "population" of outstanding DOD contracts does not exist. Instead, 12 large prime contractors provided data on monthly orders, costs, and billings. For purposes of analysis, between two and five contracts were selected from each contractor, distributed as evenly as possible by size and time of performance. The total sample (table 1) consisted of 51 contracts for major hardgood procurement items whose value approximated $2.8 billion. All of the contracts were begun prior to 1969, most beginning soon before or during the sharpest phase of the Vietnam buildup.

Production, payments, and deliveries

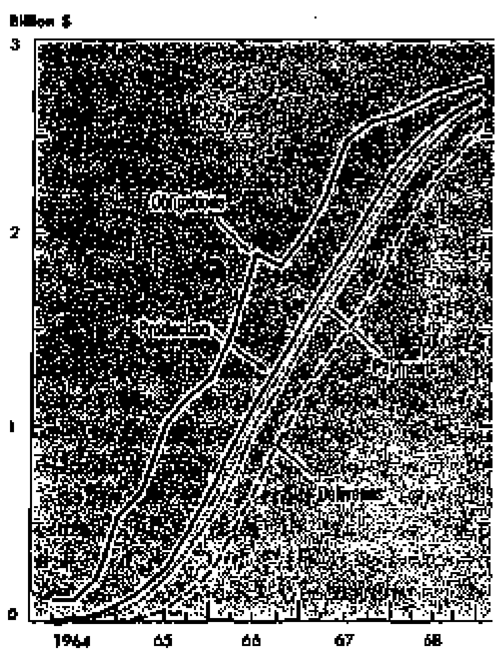
Although some economic activity associated with defense contracts, e.g., output associated with research and development, or investment in new plant and equipment, may occur before the contract orders are placed, the major impact occurs when production on the contract takes place.

The cumulative value of production at any point during the life of one of the sample contracts was approximated by the accrued costs of the prime contractor plus the contractor's final profit allocated over the life of the contract according to the time pattern of deliveries. This sum equals value added by the prime contractor plus value added by all other businesses contributing to the final output under the contract, i.e., subcontractors and their suppliers. It represents the incomes generated in production (including depreciation and indirect business taxes) and is theoretically equal to the standard definition of production as the sum of deliveries of finished goods plus inventory change.

The payments data represent the issuance of checks by DOD disbursing officers. Payments for major hardgoods reflect a blend of preproduction payments (advance payments), payments roughly coincident with production (progress payments), and payments lagging production (final payments). The major differences between payments and production occur because progress payments do not fully cover the value of production. At present, progress payments average about 85 percent of production costs, with the 15 percent balance paid only after final delivery. Because both payments and deliveries lag production, both measures are unsatisfactory indicators of changes in defense output.

CHART 10

Obligations, Production, Payments, and Deliveries, All Sample Contracts, 1964-68



U.S. Department of Commerce, Office of Business Economics 71-9-10

Chart 10 shows obligations, payments, deliveries, and production data aggregated from all 51 sample contracts. (The obligations series consists of contract awards and subsequent modifications to the contracts.) On the average, the obligations incurred on procurement items lead production by about six months while payments and deliveries lag production by about two months and six months, respectively.

Another way of depicting the relationship among payments, deliveries, and production can be seen on chart 11, which shows data calculated by beginning all 51 contracts at a hypothetical month zero and continuing them for 40 months. "Unpaid production" is production on the contracts less payments and "undelivered production" is production less deliveries.

At the end of 20 months, cumulative production exceeds cumulative payments by about $335 million, or 11 percent of total obligations, and exceeds cumulative deliveries by approximately $1 billion or more than one-third of total obligations. These sample

1. *Report of the President's Commission on Budget Concepts*, U.S. Government Printing Office, October 1967.

2. See *A Final Report on the Proceedings of the DOD Special Study Group on Defense Contractor Constructive Delivery (Accrual Accounting Implementation)*, U.S. Department of Defense, May 1970.

Table 2.—Estimated Production on Defense Procurement Contracts, Actual Payments, and Actual Deliveries

[Billions of dollars]

	Calendar Year						1964	1965				1966			
	1965	1966	1967	1968	1969	1970	IV	I	II	III	IV	I	II	III	IV
							Annual rates, not seasonally adjusted								
Production	14.7	18.8	22.8	24.0	22.8	18.4	14.2	14.1	13.8	14.9	15.8	16.6	17.1	19.8	21.6
Payments	12.4	16.2	22.0	23.4	23.4	20.4	13.7	11.6	11.0	13.4	13.8	14.6	15.5	17.6	17.1
Deliveries	13.5	15.2	20.1	22.8	23.1	20.5	14.1	13.1	12.8	14.2	13.6	14.2	14.5	16.8	17.6
Production less payments	2.3	2.6	.8	.6	−.6	−2.0	.5	2.5	2.8	1.5	2.0	2.0	1.6	2.2	4.5
Production less deliveries	1.2	3.6	2.7	1.2	−.3	−2.1	.1	1.0	1.0	.7	2.2	2.4	2.6	3.0	4.0

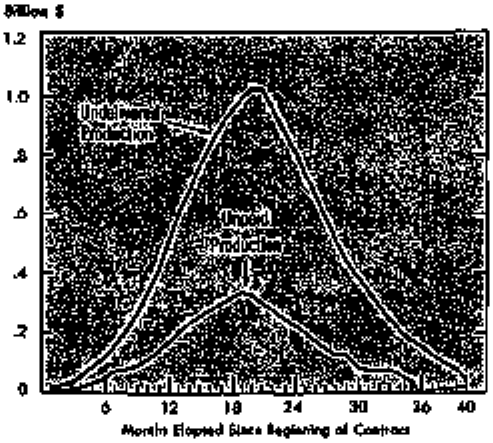
	1967				1968				1969				1970				1971	
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II
	Annual rates, not seasonally adjusted																	
Production	22.1	21.8	23.5	23.8	23.8	23.0	24.0	25.5	25.5	23.5	21.7	20.5	20.0	18.5	17.7	17.4	17.7	17.7
Payments	20.3	21.1	24.2	22.4	23.5	23.1	22.9	24.4	24.8	24.3	22.0	22.4	21.4	20.5	20.2	19.4	17.7	18.6
Deliveries	18.8	19.3	21.5	20.9	22.0	21.8	23.6	23.9	23.8	22.6	22.8	23.1	21.9	20.7	20.3	19.3	19.4	19.0
Production less payments	1.8	.7	−.7	1.4	.3	−.1	1.3	1.1	.7	−.8	−.3	−1.9	−1.4	−2.0	−2.5	−2.0	.0	−.9
Production less deliveries	3.3	2.5	2.1	2.9	1.7	1.2	.4	1.6	1.7	.9	−1.1	−2.6	−1.9	−2.2	−2.6	−1.9	−1.7	−1.3

Source: Production—Estimates by authors (Equation 16). Payments—Checks issued for Department of Defense budget category "Procurement," published in monthly issues of Defense Indicators (Series 662); quarterly average of unadjusted monthly data. Deliveries—National defense purchases of goods and services, not seasonally adjusted, modified to exclude all items except purchases in the budget category "Procurement."

data suggest that any significant increase in defense orders will result in production advancing considerably more rapidly than payments or deliveries. The data also show that when orders slacken, payments and deliveries decline less rapidly than production.

CHART 11

Cumulative Value of Undelivered Production and Unpaid Production, All Sample Contracts



NOTE.–Data plotted are 3-month moving averages of cumulative values.

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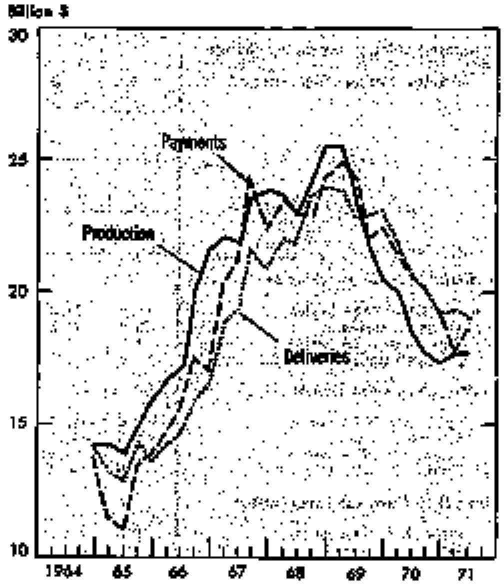
Estimates of Defense Production

Estimates of aggregate production resulting from all defense contracts for procurement items were obtained for the period 1964-IV—1971-II by use of the econometric model developed from the contract sample. The derivation and estimation of the model are described in the final section of this article. The estimates of production resulting from all defense procurement contracts (table 2) were derived with equation 16, using changes in lagged values of unpaid obligations outstanding (UO) as explanatory variables. The UO series was obtained by eliminating double-counting of intra-DOD obligations from "gross unpaid obligations outstanding for procurement" (GUOO) as published by DOD.[3]

As indicated by table 2 and chart 12, changes in payments and deliveries lagged after changes in estimated defense production during the Vietnam buildup and the recent defense slowdown. During the initial buildup from the fourth quarter of 1964 to the fourth quarter of 1966, estimated production on defense procurement contracts increased from $14.2 billion (annual rate) to $21.6 billion, a rise of

CHART 12

Estimated Defense Production, Actual Payments, and Actual Deliveries, 1964-71



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3. The data in table 2 on production, payments, and deliveries, and the UO series used in deriving estimated production, all refer to the DOD budget category "Procurement." The principal items included in the "Procurement" account are aircraft, ships, tracked combat vehicles, ordnance (including missiles), vehicles and related equipment, and electronics and communication equipment.

$7.4 billion. In the same period, payments on defense procurement contracts increased only $3.4 billion and deliveries only $2.6 billion. In the slowdown period, estimated production decreased from a rate of $25.5 billion in the fourth quarter of 1968 to $17.4 billion in the fourth quarter of 1970, a drop of $8.1 billion. In the same period, payments and deliveries declined only $5.0 billion and $4.7 billion, respectively.

The gaps were widest in the second half of 1966, when production exceeded payments by $3.3 billion (annual rate) and deliveries by $4.4 billion. These data strongly suggest the inadequacy of either payments or deliveries data in providing economic analysts and policymakers with information on the magnitude or the timing of defense activity during periods of rapid change. This strongly supports the desirability of developing additional statistical estimates of defense activity and its impact within the framework of the national income and product accounts.

Adjusting the NIA Data

By the standard definition used in the national accounts, production is the sum of deliveries (purchases) of finished goods plus inventory change. Thus, an estimate of defense-related inventory change in the private sector can be derived as a residual by subtracting deliveries from the estimate of production. This is shown as the last line in table 2. Although none of the data in table 2 are seasonally adjusted, it is assumed in the following steps that the estimated series on defense inventory change has no significant seasonality.

If estimated defense inventory change is added to the published NIA defense purchases series, the latter is converted to something much more closely ap-

Table 3.—Published and Adjusted Series for National Defense Purchases, Federal Surplus or Deficit, and Change in Business Inventories

[Billions of dollars]

	Calendar Year						1964	1965				1966			
	1965	1966	1967	1968	1969	1970	IV	I	II	III	IV	I	II	III	IV
							Seasonally adjusted at annual rates								
National defense purchases:															
Published NIA series	50.1	60.7	72.4	78.3	78.4	75.4	49.0	48.6	49.2	50.1	52.5	55.3	58.5	63.3	65.6
Adjusted series	51.3	64.2	75.1	79.5	78.1	73.3	49.0	49.6	50.2	50.8	54.7	57.7	61.1	67.2	70.5
Change in NIA series	....	10.6	11.7	5.9	.1	−3.0	....	−.4	.6	.9	2.4	2.8	3.2	4.8	2.3
Change in adjusted series	....	12.9	10.9	4.4	−1.4	−4.8	....	.6	.6	.6	3.9	3.0	3.4	6.1	3.3
Federal surplus or deficit (−):															
Published NIA series	1.2	−.2	−12.4	−6.5	7.3	−12.6	−.6	4.4	4.7	−3.1	−1.1	1.4	3.0	−1.2	−4.1
Adjusted series	.9	−2.7	−15.1	−7.7	7.6	−11.5	−.7	3.4	3.7	−3.8	−3.3	−1.0	.4	−5.1	−9.0
Change in NIA series	....	−1.4	−12.2	6.0	13.8	−20.0	....	5.0	.3	−7.8	2.0	2.5	1.6	−4.2	−2.9
Change in adjusted series	....	−3.7	−11.4	7.4	15.3	−19.1	....	4.1	.3	−7.5	.5	2.3	1.4	−5.5	−3.9
Change in business inventories:															
Published NIA series	9.6	14.8	8.2	7.1	7.4	2.8	7.7	10.9	8.9	9.1	9.7	11.3	16.2	11.0	10.0
Adjusted series	9.4	11.3	5.5	5.9	7.7	4.9	7.6	9.9	7.9	8.4	7.5	8.9	13.6	8.0	15.0
Change in NIA series	....	5.2	−6.6	−1.1	.3	−4.6	....	3.2	−2.0	.2	.6	1.6	4.9	−4.3	6.0
Change in adjusted series	....	2.0	−5.8	.4	1.8	−2.8	....	2.3	−2.0	.5	−.9	1.4	4.7	−5.6	7.0
Estimated defense inventory change:															
(Production less deliveries)	1.2	3.5	2.7	1.2	−.3	−2.1	.1	1.0	1.0	.7	2.2	2.4	2.6	3.9	4.9

	1967				1968				1969				1970				1971	
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II
	Seasonally adjusted at annual rates																	
National defense purchases:																		
Published NIA series	70.8	71.8	73.0	74.7	76.5	78.3	79.1	79.4	78.3	77.5	79.4	78.4	79.0	75.1	74.2	73.2	73.0	71.8
Adjusted series	73.2	74.3	75.1	77.6	78.2	79.5	79.5	81.0	80.0	78.4	78.3	75.8	77.0	72.9	71.6	71.3	71.3	70.5
Change in NIA series	4.3	1.0	1.2	1.7	1.8	1.8	.8	.3	−1.1	−.8	1.9	−1.0	.6	−3.8	−.9	−1.0	−.2	−1.2
Change in adjusted series	2.7	1.1	.8	2.5	.6	1.3	.0	1.5	−1.0	−1.6	−.1	−2.5	1.2	−4.1	−1.3	−.3	.0	−.8
Federal surplus or deficit (−):																		
Published NIA series	−11.6	−12.5	−13.1	−12.3	−9.8	−11.2	−3.9	−1.1	9.1	11.7	5.1	3.4	−4.5	−14.1	−15.4	−20.5	−17.5	−22.6
Adjusted series	−14.9	−15.0	−15.2	−15.2	−11.5	−12.4	−4.3	−2.7	7.4	10.8	6.2	6.0	−2.6	−11.0	−12.8	−18.6	−14.2	−21.3
Change in NIA series	−7.4	−.9	−.6	.8	2.5	−1.4	7.3	2.8	10.2	2.6	−6.6	−1.7	−7.9	−9.6	−1.3	−5.1	3.0	−5.1
Change in adjusted series	−6.9	−.1	−.2	.0	3.7	−.9	8.1	1.6	10.1	3.4	−4.6	−.2	−8.6	−8.4	−1.8	−5.8	4.4	−7.1
Change in business inventories:																		
Published NIA series	9.6	4.5	8.7	10.0	2.9	9.6	7.7	8.1	6.6	6.8	10.4	5.7	.4	2.1	5.1	3.7	3.2	5.7
Adjusted series	6.3	2.0	6.8	7.3	1.2	8.4	7.3	6.5	4.9	5.9	11.5	8.3	2.3	4.3	7.7	5.6	4.9	7.0
Change in NIA series	−10.3	−5.1	4.2	1.3	−7.1	6.7	−1.9	.4	−1.5	.2	3.6	−4.7	−5.3	1.7	3.0	−1.4	−.5	2.5
Change in adjusted series	−.7	−4.3	4.8	.5	−6.0	7.2	−1.1	−.8	−1.6	1.0	5.6	−3.2	−6.0	2.0	3.4	−2.1	−.7	2.1
Estimated defense inventory change:																		
(Production less deliveries)	3.3	2.5	2.1	2.9	1.7	1.2	.4	1.5	1.7	.9	−1.1	−2.6	−1.9	−2.2	−2.6	−1.0	−1.7	−1.3

Source: Estimated defense inventory change—table 2. NIA Series—various issues of the SURVEY (see "Historical Statistics" note on page 10).

proaching a defense production series.[4] This adjustment is shown in table 3, along with the associated adjustments in the change in business inventories component of GNP—from which defense-related inventory change is subtracted—and in the Federal surplus or deficit on the NIA basis—which is adjusted to reflect defense production rather than purchases (deliveries). These adjustments do not affect total GNP, only its composition.

The published NIA defense purchases series rose $10.6 billion in 1966 and $11.7 billion in 1967, and fell $3.1 billion in 1970. Adjusted to a production basis, however, the series shows an increase of $12.8 billion in 1966 and $10.9 billion in 1967, and a decline of $4.9 billion in 1970. Consequently, the Federal budget position, after adjustment to make defense spending coincide with production, shows a steeper shift into deficit in 1966 and a somewhat smaller shift into deficit in 1970.

On a quarterly basis, a similar picture emerges from the data in table 3. During the sharpest phase of the Vietnam buildup, from late 1965 through 1966, the quarterly increase in the adjusted defense spending series consistently exceeded the increase in the published NIA defense purchases series. The situation was opposite during the de-escalation phase in 1969 and 1970, when adjusted defense spending generally decreased much faster than the published NIA series. Similarly, the Federal fiscal position, as adjusted, suggests (1) a considerably more expansionary fiscal policy during during 1965–66, and (2) a more restrictive stance since 1969, than indicated in the published figures on the NIA surplus or deficit.

Possible Data Problems

There are a number of hazards in applying the model and coefficients developed from the sample to the much larger, and perhaps much different, total population of defense procurement contracts.

First, as indicated earlier, the sample of 51 contracts is neither a random nor a representative sample of the total population of defense procurement contracts. It consists primarily of Navy and Air Force aircraft, missile, and electronics contracts. Omitted completely are ship construction and "soft-goods" contracts as well as Army and Marine Corps contracts. Since much of the production buildup associated with the Vietnam conflict involved such items as ammunition, rifles, etc., necessary to fight a conventional war, use of a contract sample heavily weighted toward more sophisticated, strategic weapons could significantly bias the estimators.

Second, it is unlikely that the profit rate on procurement contracts is constant over time, as assumed in this study. The value of aggregate production on all procurement contracts was estimated by use of the relationship between production and unpaid obligations established from the sample. Since profits are included in the value of production, the average rate of profit on the sample contracts was in effect assumed to hold for all procurement contracts. While the assumption that the sample contracts generated "typical" rates of profit is considered reasonable, there is no doubt that profit rates on defense contracts may fluctuate from year to year. As a result, actual fluctuations in production may be obscured if they are accompanied by shifting profit margins.

Third, the adjustments made to the GUOO series to eliminate double-counting may be inadequate. Double-counting occurs when one military service obligates funds to another service to procure certain goods from private contractors. Both the intra-Defense Department obligations and the obligation to the contractor are counted in the published GUOO series. The exact extent of double-counting is not known, but estimated at about 15 percent to 25 percent of GUOO in the 1964–69 period. To correct for double-counting, the published data were lowered by a constant 20 percent, a ratio suggested by certain Defense Department data.

Fourth, the published GUOO series excludes obligations by revolving and management funds, which serve as intermediaries between the obligating military service and the private sector for the procurement of many items. Obligations by such funds may precede or lag the related obligations in the GUOO series, and this can distort the timing relationship between the GUOO series and production. For example, an obligation entered into the GUOO series for goods already in the inventory of a revolving or management fund will lag the original obligation by the fund for the procurement of the goods. Conversely, obligations entered into GUOO can precede obligations by the funds if the goods to be procured have yet to be manufactured.

Any of the data problems noted above could introduce systematic bias in the production estimates, but the extent of such bias cannot be determined. It is hoped that the bias is small and does not seriously distort the implications of this analysis.

Derivation of Model

We start with a model in which new orders for defense procurement items (NO) placed in a given period will lead to production (Q) in the same and subsequent periods in a pattern of fixed proportions (A_i) to the initial NO. This model is represented by the following equation:

$$(1)\quad Q_t=\sum_{i=1}^{n} A_i\, NO_{t-i+1}$$

where

$\sum_{i=1}^{n} A_i=1$, and n is the number of periods in which production on an NO occurs.

Next, we introduce an identity involving Q, NO, and unproduced orders (UO), as follows:

$$(2)\quad \Delta UO_t=NO_t-Q_t.$$

Substituting (1) in (2) we obtain

$$(3)\quad \Delta UO_t=NO_t-\sum_{i=1}^{n} A_i\, NO_{t-i+1}.$$

Next, we want to write (3) so that it involves only ΔUO and Q. To do so,

4. The estimates of defense production and inventory change are for items included in the "Procurement" category of the DOD budget (see footnote 3). It is those goods for which significant deviations occur between the time of actual production and the times of payment and delivery. In 1970, deliveries (purchases) of "Procurement" items accounted for about $20.5 billion (table 2) of the $75.4 billion total NIA defense purchases; the remainder consisted of: employee compensation, $33.3 billion; structures, $1.4 billion; and all other goods and services, $20.2 billion.

we introduce the lag operator $A(L)$[5] where

$$(4)\quad A(L)=A_1+A_2L+A_3L^2+\dots+A_nL^{n-1}.$$

Substituting (4) in (3) gives

$$(5)\ \Delta UO_t=NO_t-A(L)NO_t,\ \text{or}$$

$$(6)\ \Delta UO_t=[1-A(L)]NO_t,\ \text{or}$$

$$(7)\ \frac{1}{1-A(L)}\Delta UO_t=NO_t,\ \text{or}$$

$$(8)\ B(L)\Delta UO_t=NO_t\ \text{if we set}\ B(L)=\frac{1}{1-A(L)}.$$

Substituting (8) in (2), we have

$$(9)\ \Delta UO_t=B(L)\Delta UO_t-Q_t,\ \text{or}$$

$$(10)\ Q_t=[B(L)-1]\Delta UO_t.$$

We have now replaced an expression involving Q and NO by one involving Q and ΔUO.[6] Next, we derive the regression equation actually used. If we define $[B(L)-1]$ in (10) as $G(L)$, we can expand (10) to read as follows:

$$(11)\ Q_t=G_1\Delta UO_t+G_2\Delta UO_{t-1}+G_3\Delta UO_{t-2}+\dots.$$

This form can be changed further by introducing the level of UO_t into the equation. We can write the level of UO at time t as a sum of changes in UO's

$$(12)\ UO_t=\Delta UO_t+\Delta UO_{t-1}+\Delta UO_{t-2}+\dots$$

and when (12) is multiplied by a constant, a^*, we obtain

$$(13)\ a^*UO_t=a^*\Delta UO_t+a^*\Delta UO_{t-1}+a^*\Delta UO_{t-2}+\dots$$

Subtracting the right-hand-side of (13) from its left-hand-side and adding the resulting expression (whose value is zero) to the right-hand-side of (11) yields

$$(14)\ Q_t=a^*UO_t+(G_1-a^*)\Delta UO_t+(G_2-a^*)\Delta UO_{t-1}+(G_3-a^*)\Delta UO_{t-2}+\dots.$$

The value of the constant, a^*, in (14) is derivable from the lag operator $B(L)$. a^* can be seen also as equaling the ratio of the average Q on an NO over the n periods required to produce the NO to the average UO associated with that same NO. This, in turn, equals the ratio of Q to UO in a situation in which a constant level of NO has been maintained for at least n periods.[7]

Redefining the terms in parentheses in (14) as $(G_i-a^*)=a_i$, we have the final form of the equation as used in this study:

$$(15)\ Q_t=a^*UO_t+a_1\Delta UO_t+a_2\Delta UO_{t-1}+a_3\Delta UO_{t-2}+\dots.$$

The introduction of a^* and the level of UO has a distinct advantage over the use of the lag structure obtained on the basis of change terms only. Depending upon the original distribution of the A_i and the associated convergent properties of the lag operator, the a_i given in (15) can become very small after only a few terms. This can be seen from an examination of the terms in parentheses in (14) where convergence of the G_i to a^* implies convergence of the a_i to zero. In the present study, as will be seen from an examination of the regression results given below, the underlying production parameter (A_i) distribution led to a very short effective lag structure, from which rapid convergence could be inferred.

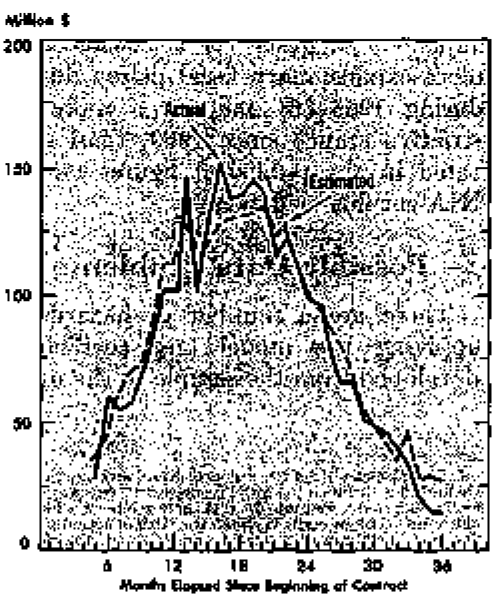
Further comments on model

The following comments are intended to round out the foregoing explanation of the model. First, the considerations that led to the adoption of a model involving fixed production lags are not discussed in this report. Second, the relation between Q and UO was substituted for the more transparent relation between Q and NO primarily because the latter involved a very long lag and it was desirable to circumvent the practical difficulties that arise when long lag structures must be estimated from a small sample of observations. Third, unpaid orders were substituted for unproduced orders (UO) because the GUOO series relates to unpaid rather than unproduced orders, and the GUOO series (adjusted to eliminate double counting) was to be used in estimating production under the total of all procurement contracts; the sample series had to be defined correspondingly so that the relationships derived from the sample could be used to estimate total production under all contracts. Fourth, the regression techniques were applied

(*Continued on page 51*)

CHART 13

Actual and Estimated Production, All Sample Contracts



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5. See, for example, Zvi Griliches, "Distributed Lags: A Survey," *Econometrica*, January 1967.

6. Valid use of the lag operator technique requires that the derived lag be dynamically stable. Stability depends on the roots of the polynomial given by 1-A(L). For the model used in this study, stability is always assured because the A_i as defined in equation (1) are always positive. Examination of the lag operator term in (7) shows that the lag derived on ΔUO will not terminate. As will be shown, however, a transformation which involves the level of UO can result in effective lags which are very short.

7. This can be shown for a case involving only three periods to produce an NO. Let the NO=10, A_1=.3, A_2=.5, and A_3=.2; then average Q=(3+5+2)/3=10/3, average UO=(7+2+0)/3=9/3, and their ratio is 10/9=1.11111. The same value can be obtained via the lag operator as follows: The denominator given in (7), evaluated with the A_i given here, is $(.7-.5L-.2L^2)$. This can be factored into $(1-L)(.7+.2L)$. Thus, the fractional operator term in (7) can be expressed in partial fractions as

$$\frac{1}{.7-.5L-.2L^2}=\frac{C_1}{(1-L)}+\frac{C_2}{(.7+.2L)}.$$

In this expression, $C_1=a^*$. The constants C_1 and C_2 are obtained by multiplying the numerators and denominators of the right-hand terms so as to obtain a common denominator and then multiplying both sides of the equation by $.7-.5L-.2L^2$ to yield $C_1(.7+.2L)+C_2(1-L)=1$. Setting L=1, we obtain $C_1=1/.9=1.11111$, the same value for a^* as obtained above. Setting L=0, we have $C_1(.7)+C_2=1$, or, after substituting the value for C_1, $C_2=.2/.9=.22222$. Using the second partial fraction and the value for C_2, on division we obtain

$$.22222/(.7+.2L)=.31746-.09070L+.02591L^2-.00740L^3+.00211L^4-\dots$$

Thus, the full lag given by (7) contains in addition to the constant value a^* a component with alternating signs which converges to zero. The speed of convergence is entirely a function of the A_i. The set of coefficients derived above from C_2 can be identified with the a_i coefficients (a_1, a_2, a_3, . . .) given in equation (14) which are deviations from the constant value a^*.

spending for plant and equipment is not limited by OFDI regulations.

Affiliates in Schedule B countries (including the United Kingdom, Japan, and Australia) except to increase spending 12 percent in 1971 and 4 percent in 1972 to $4.2 billion. Affiliates in Schedule A countries (including most of the less developed countries), for which controls on capital outflows are most lenient, show the largest growth in 1971—a rise of 16 percent. An increase of 8 percent to $4.0 billion is expected in 1972.

Note on methodology

The spending projections presented here were prepared with a revised method to eliminate—or at least reduce—any systematic bias in responses to the four expectations surveys taken for each year (in June and December of the preceding year and June and December of the year in question, i.e., *A*, *B*, *C*, and *D* reports). The revised method has two primary advantages over the old method. (For a complete discussion of the old method see the technical note on page 46 of the March 1969 issue of the SURVEY.) The first advantage of the new method is that it relies on experience over the last 5 years to adjust for possible bias in the current projection. The second advantage is that the method is applicable at disaggregated levels, thus making possible tabulation of cell data on a bias-adjusted basis.

The first step under the new method was to calculate, for the 1971 *C* and 1972 *A* reports separately, ratios of actual spending (the final *E* estimate) to the reported expectation, for each of the previous 5 years. No bias adjustment was made unless there was a deviation in the same direction in at least 4 of the 5 years. Also, no adjustment was made to items below $10 million. When an adjustment was necessary under these criteria, the median ratio of actual to expected spending in the 5-year period was applied as an adjustment factor.

The decision as to whether the first (*A*) and second (*B*) survey estimates for a given year need adjustment must be made without actual/expected ratios for the preceding year since there are no actual figures yet available for that year. In deriving the bias-adjusted 1972 data presented here, the years 1966–70 were used since actual data for 1971 are not available. In calculating bias adjustments for the third (*C*) and fourth (*D*) estimates of 1972 spending, the years 1967–71 will be used since final 1971 data will be available.

The tables published in this article were prepared by applying the "four out of five" rule at or below the lowest published country-industry data cell and then summing up to the published totals by industry and area.

A comparison of bias-adjusted projections derived under the old and the new methods indicates only minor differences for the 1971 *C* projection but major differences for the 1972 *A* projection:

	Million $		Percent change from preceding year	
	Old	New	Old	New
1971	14,830	14,686	14	12
1972	16,646	16,104	6	10

(*Continued from page 26*)

to the sample data after they had been rearranged so that production on all sample contracts was treated as beginning at the same time, i.e., in a hypothetical month zero. This rearrangement of the sample data was designed to deal with certain difficulties that stemmed from contract renegotiations. It is apparent that these two modifications of the basic Q–UO model may introduce errors into the calculations. Attempts to define the direction, let alone the magnitude, of these possible errors in a manner helpful to the evaluation of the results have been unsuccessful. Other limitations of the study are discussed in the previous section which deals in greater detail with the sample data.

Estimation of the model

Equation (15) was estimated using an Almon lag. A second degree polynomial was used with the restriction that the coefficient (a_4) of the last lagged variable have the value of zero. This was justified, because the influence of successive UO's diminished quickly.[8]

$$(16)\ Q_t = .0989\,UO_t - .1173\,\Delta UO_t - .0824\,\Delta UO_{t-1} - .0433\,\Delta UO_{t-2}$$
$$(52.3) \qquad (-4.13) \qquad (-6.79) \qquad (-2.31)$$

$R^2 = .951$, Durbin Watson statistic $= 1.10$, standard error/mean of dependent variable $= .118$, t ratios in parentheses.

The coefficients on the lagged variables deteriorate smoothly to zero, the t ratios for a^*, a_1 and a_2 are significant at the 99.5 percent level of confidence, and the t ratio for a_3 is significant at the 97.5 percent level. With 33 observations and a Durbin Watson statistic of 1.10, the hypothesis that significant autocorrelation of the error terms exists is not accepted at the 97.5 percent level of confidence.

The actual and predicted values of production on the sample contracts are shown on chart 13.

8. A third degree polynomial and different lag lengths were also tested.